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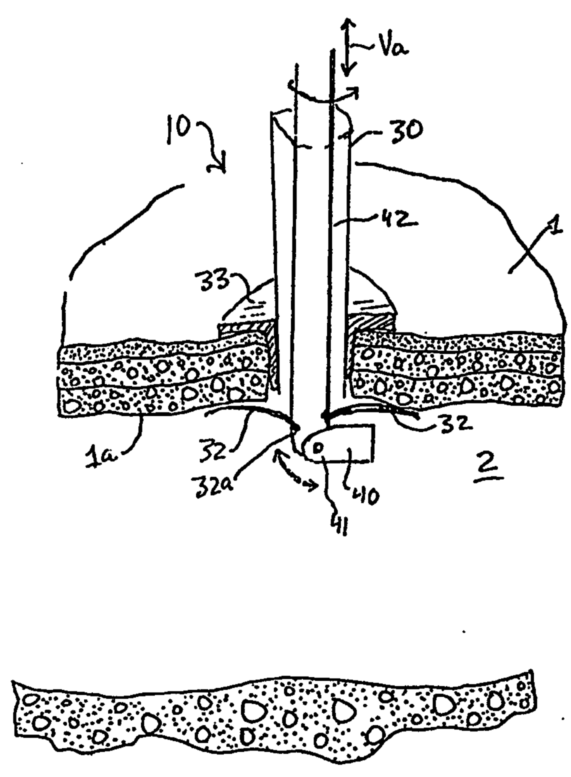
(54) Title: AUXILIARY THORACIC ENDOSCOPE FOR MINIMALLY INVASIVE SURGERY

(57) Abstract

An auxiliary endoscope useful for minimally invasive thoracic surgery has an imaging assembly with a fixation mount to position the assembly on the roof of the chest cavity. In one embodiment, the imaging assembly is a CCD camera assembly, and an outer shell closes over the camera to provide a closed cover for penetrating insertion. Once inserted, the shell opens out, umbrella-like, to form a stabilizing anchor or base contacting the chest wall. The camera has a panoramic view, and is rotatable about a support axis to face a selected direction in the horizontal plane, and is preferably movable about an axis transverse thereto to adjust vertical perspective. A supporting shaft may slide to raise or lower the camera. In one embodiment, the imaging assembly is an imaging array sensitive to IR or thermal radiation. A cooler, which in different embodiments is within the camera or outside the chest cavity, limits or controls temperature of the imaging array. In another or further embodiment, the assembly includes a light outside the cavity, with a relay or jumper extending to an output face on the camera. In other embodiments the unit may operate without its own light source, or without extrinsic illumination. The camera assembly may include a zoom element to vary magnification of its image field.



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AUXILIARY THORACIC ENDOSCOPE FOR MINIMALLY INVASIVE SURGERY

Background

The present invention relates to surgical endoscopes and more particularly to endoscopes for use in minimally invasive surgery. Such surgery is performed through relatively small incisions rather than a larger surgical opening, and relies for visualization of the operative field on an endoscope, which is generally a video camera that produces a video image displayed on a large monitor. Endoscopes for this application are generally long and thin assemblies, for example mounted on a stick or cannula-shaped body, which contains either an image relaying arrangement of lenses, a coherent fiber bundle for relaying the image, or else includes an imaging assembly such as a CCD image pick-up at the distal end of the elongated body and with electrically conductive leads extending from the CCD. Such endoscopes generally also include an illumination fiber bundle which brings light down to the region of the imaging or camera lens and which illuminates the field of view.

Generally for thoracoscopic surgery, the viewing endoscope is handled and operated by a dedicated operating room assistant, and may have a very short focal length and working distance. This allows the operator to position the endoscope close to a site, for example the site of cutting, or of incisions for harvesting a small vessel during surgery, or removing a tissue specimen.

Surgical endoscopes for this application generally have a series of small diameter lenses, e.g., rod lenses adapted to relay an image from an objective assembly to an eyepiece, or else have an objective which directly images onto a CCD element or video pick-up under about one centimeter in cross dimension. The optics may have a field of view between about 50° to over 100°, and a working distance generally on the order of one half to two inches. This allows the camera to be sufficiently close to the surgical instrument to effectively image the details of surgery.

One drawback of a typical endoscope with a field of view of about 50° is that to obtain a sufficiently enlarged view to perform tasks such as dissecting and suturing tissue, clipping vessels, and the like, the endoscope must be moved closer to the tissue and constantly re-positioned as the surgery proceeds. Advancing the endoscope narrows the actual view, and operating at a working distance of about one inch, the surgeon may also have a distorted or partially obscured view of even a simple structure, such as a vessel or small nodule, or may lose track of where in the operating theater he is actually performing. It is then necessary to retract the endoscope to obtain a wider field of view.

For thoracoscopic surgery, where the chest cavity includes the heart and lungs, and numerous vascular structures, and in which a typical procedure may involve cutting into the chest wall to harvest one or more blood vessels (for example when performing cardiac bypass grafting), it is important for the surgeon to maintain a larger perspective of the arena within which he works, and a view of adjacent organs or tissue structures. This is necessary, for example, to guide an instrument being inserted through one incision to a site being worked on with the tip of another instrument that has previously been placed through a different incision.

Such a perspective or larger-field view is generally accomplished by drawing back the endoscope to bring the second incision into its field of view, then re-positioning it as necessary to continue operating. In theory, a supplemental view could also be obtained by taking a second endoscope and inserting it through a different opening to view the surgical arena from a different vantage point or angle, or with different overall magnification or field of view. The manipulation of the second endoscope would then require care to determine and maintain its position, to keep the surgical locus in the field of view and to correlate the site shown in one endoscope with the site imaged by the other. This task is especially difficult if one considers the number of instruments and incisions already involved in an operation and the limited visibility and the intervening structures present when performing a resection, excavating a vessel or doing other surgical intervention in an endoscopic or endoscope-assisted setting.

A number of devices or systems for obtaining adequate views have been previously proposed to address related problems in the field of laparoscopic or bronchoscopic surgery or endoscopic biopsies. Thus, in situations where the endoscope is inserted along a body passage and is used for mapping or viewing features on the passage, various arrangements of multiple imaging sites and corresponding video synchronization, or screen-within-a-screen processing have been proposed. However, the situation of viewing polyps in the colon, or other features within a tubular passage differs substantially from the problem posed by imaging a surgical arena in which, for example, instruments are inserted and tissue excavation or resection is carried out in a relatively large body cavity, such as the chest cavity, in and around a variety of tissues or mobile or moving organs. In the latter context, there is no natural channel guiding the endoscope, and the extent of the operating arena may be quite large and include a number of occluding structures around the surgical site itself.

Thus there remains a need for improvement in endoscopic systems for such surgical use.

Summary of the Invention

An endoscopic system according to the present invention is characterized by an auxiliary endoscope which provides a fixedly-positioned view of a body cavity. The endoscope includes an introduction system in which an imaging element at the tip of a cannula or shaft penetrates a small incision and mounts on the roof of the chest cavity where it provides a wide angle and preferably a panoramic view of the cavity. In one embodiment, the endoscope includes a shaft or body with an imaging unit such as a CCD at its distal end, and incorporates an introducer assembly in which a plurality of petal-like elements close over the imaging unit to form a covered tip which encloses and protects the unit during introduction of the assembly through an incision. Upon insertion, the petals open back and bear against the inside of the roof of the chest cavity to form a supporting platform which maintains the introducer assembly locked against the chest opening and clamped on the chest wall.

The supporting shaft of the imaging unit may slide axially in a vertical direction to raise or lower the imaging element, and may rotate about its axis to scan to the left, right, head or abdomen directions in the cavity. Preferably the imaging unit also tilts about an axis perpendicular to the axis of the shaft, to raise or lower the perspective angle of the field of view subtended by the imaging optics. However, the unit remains fixed on its support shaft.

In a preferred embodiment the imaging element is a panoramic imaging element having a field of view of 100° or more, with a focus encompassing object planes from approximately one-half inch to infinity. It is thus effective to view surgical loci at all points in the pleural region or within the rib cage and extending up toward the patient's head. An internal zoom element may be provided to allow increased magnification of more distant structures. An illumination assembly for this embodiment may include a short fiber bundle to couple light relatively unattenuated over the small distance from the outside of the chest cavity to a distal emission face on the camera. The bundle may receive illumination either from a conventional fiber-optic illumination source, or from a lamp assembly attached directly to or supported on the proximal end of the support shaft. The video output from the imaging unit is processed in a conventional fashion to display a wide angle field of view within the cavity. This view in general will include an image of the surgical implements and the primary endoscope, which may for example be introduced through one or more incisions or openings several inches away and directed to a surgical site which may be even more remote. Preferably the view is presented on a display as a window, together with the image formed by the primary scope.

According to another aspect of the invention, the endoscope may utilize a spectral band distinct from that of the primary operating scope, and may for example be provided with an optical filter, or a post-imaging digital filter, to selectively image particular colors or wavelengths. Thus, for example, it may display fluorescence emitting necrotic or diseased tissue, may display the color emanating from a marked drug or chemical such as a fluorescent dye, or may selectively display an image processed to enhance vessel contrast. Alternatively, the sensor itself may be a special unit configured to image infrared illumination in the 1-15 micron band, or in sub-bands such as the 1-5 and/or 8-12 micron bands to allow thermal and to some extent depth imaging of tissue and provide visualization of blood vessels and similar structures. In that case, the endoscope may also operate purely with infrared imaging, and employ no external light source, or only a low intensity source, to create simultaneously a thermal image and optionally a correlated visual video image. In this case, twin objective optics and filters may be provided for the imaging unit to image the IR and the imaging wavelengths for example, both infrared and yellow/green wavelengths. The CCD itself may be a specialized CCD having separate filters or color receiving pixels interleaved for forming two different spectral band images simultaneously. The thermal imaging embodiment may include a Peltier type cooler, e.g., a thermoelectric cooler, which maintains the CCD or imaging chip at a lowered temperature to reduce overall noise. Alternatively, a cooling assembly may be provided externally of the chest, and a heat pipe may couple the cooler to the CCD to maintain the temperature of the imaging chip below body ambient. In still other embodiments, the imaging chip may employ a high-temperature IR sensing array elements so that no additional cooling is required. The invention also contemplates that in other embodiments, the panoramic scope may have an optical relay or coherent bundle imaging assembly extending to the distal end, with image formation and video conversion occurring outside the chest at the proximal end in a more controlled thermal environment.

Brief Description of the Drawings

These and other features of the invention will be understood from the description below taken together with drawings of illustrative embodiments wherein,

FIGURE 1 illustrates a thoracic auxiliary endoscope according to the present invention in an operative setting;

FIGURE 2 illustrates one embodiment of the endoscope shown in FIGURE 1 in a cross-sectional view during insertion;

FIGURE 3 shows the endoscope of FIGURE 2 in its inserted and operative position;

FIGURE 4 illustrates a system of the invention;

FIGURE 4A illustrates a front view of the camera in the system of FIGURE 4;

FIGURE 5 illustrates another embodiment having an illumination unit; and

FIGURE 6 shows another embodiment.

Detailed Description

FIGURE 1 shows an auxiliary endoscope 10 for minimally invasive thoracic surgery in accordance with the present invention. The endoscope 10 is mounted on a patient 100 through an incision 12 penetrating the chest wall 1 to access the chest cavity via the upper wall thereof. As shown, the endoscope 10 has a mounting assembly which attaches it to the chest. The endoscope is mounted and aimed internally to visualize tissue such as lungs 14, heart 16 and the chest lining (not numbered). One or more other incisions or openings illustrated by incision 12a are provided through which surgical instruments and a primary endoscope 20 may be inserted to the region of a surgical locus which is generally observed by the primary scope 20. The primary scope 20 may, for example, have a working distance of 1/2 to 3 inches and a field of view 50°-80°. The field of view of the endoscope 10 on the other hand, encompasses the surgical locus and the various instruments extending thereto. Primary endoscope 20 is of the type manipulated by the hand of an operating room assistant, whereas endoscope 10 of the present invention is mounted in a fixed position on the roof of the chest cavity.

FIGURE 2 illustrates one preferred embodiment of the auxiliary endoscope 10 of the present invention for thoracic surgery. As shown, endoscope 10 extends through a cannula assembly 30 and includes an imaging assembly 40. The imaging assembly 40 mounts on a supporting shaft or column 42 that fits within the cannula assembly 30 and is oriented and held thereby. The cannula 30 is a tapered cannula, and preferably the assembly constitutes a trocar in that it extends to a distal end point 31, formed by a plurality of petal-like plates or shells 32 which close together into a pointed generally

bullet-shaped cover over the imaging assembly 40. This constitutes a pointed protective sheath over the imaging assembly for introduction through the opening 12. An annular bushing 33 is also shown which fits closely with the wall of cannula 30 and defines a rigid support surface at the opening 12. As shown, the imaging assembly 40 which is preferably a CCD imager, is a small thumb-nail size assembly mounted on the distal end of supporting column 42 and enveloped within the enclosing structure of shells 32.

FIGURE 3 illustrates the endoscope of FIGURE 2 in its fully inserted position. In this position, the shells 32 are pivoted back about hinges 32a and bear against the upper inside surface 1a of the chest wall 1. They thus form a mounting pedestal or clamped support which, in conjunction with the bushing 33, stably locks the cannula 30 in a position at the top of the chest cavity with the imaging assembly 40 aimed outward therefrom within the cavity. As shown, the supporting column 42 on which the imaging assembly 40 is mounted can move vertically along the axial direction indicated by V_a to raise and lower the camera, and may rotate around the axis of that column to direct the field of view in a 360° sweep or scan around the inside of the thoracic cavity. The small imaging assembly 40 at the end of support 42 may also pivot around a pivot axis 41 extending across the axis of the column 42 to raise or lower the perspective angle of the view within the cavity. Each of these rotation or slide movements or settings is preferably a manual motion which is locked by a simple twist locking assembly or detent, implemented with mechanical elements of a type well known in the mechanical arts to enable the user to simply set the direction at which the camera is aimed once it is fixed on the roof of the cavity, or reset it if necessary as the surgical locus of interest changes. The camera thus remains at a fixed vertical axis, namely that of column 42.

While not shown in the above cross-sectional drawings, the invention further contemplates that an illumination fiber bundle pass with or within the column 42 to an output face which as is known is generally arrayed around the image receiving face of the imaging assembly 40 so as to illuminate everything within the field of view faced by the assembly 40. Such a fiber bundle may terminate in a series of divergent fiber ends or lensing elements which match the area they illuminate to the field of view of the imaging assembly 40.

As shown in FIGURE 4, the imaging assembly 40 includes a housing 43 which as mentioned above pivots around pivot point 41 on the column 42. Housing 43 encloses an optical assembly, illustratively a lens 46 which images a panoramic field of view on a CCD or other electronic imaging element 48. According to a further aspect of the invention, the imaging assembly, while located on a fixed vertical shaft, has a zoom objective assembly, which is preferably implemented by an internal movable element 46' shown schematically. This may be a lens or lens grouping which moves, optionally in

conjunction with translation of the sensing array 48 as described in commonly owned U.S. Patent 5,575,757. Arrayed around the image forming and sensing portions 46, 48 are a plurality of optical fibers or light guides 51 which are supplied with light by a fiber bundle 50 that extends upward, preferably through the support column 42, to a light port 55 on the outside of the cannula.

FIGURE 4A shows a front view of the face of the imaging assembly 40. As shown, the lens 46 is located at the center, and the optical fiber light output faces 51 are positioned in an annular region about the lens so as to direct their light forwardly over the field of view encompassed by the lens. The fibers 51 may be replaced by other forms of light pipe such as a molded plastic assembly, and the fibers need be neither coherence- or polarization- preserving, nor in general ordered in any particular fashion. However, they are preferably selected to have high transmissivity at the illumination or viewing wavelengths, so that minimal light loss or heat generation occurs in the fibers themselves. This assures that the housing 43 maintains a relatively stable temperature and does not cause the CCD imaging device to develop excessive noise. The fibers, or light output face if a separate face is provided, preferably also have a divergence, or numerical aperture, matched to the view of lens 46.

Each of the cables, i.e. the image conducting wires 49 to the CCD and the light conducting fibers or bundle 50 to the illumination face 51, extend from the imaging assembly 40 up through the column 42 to the outside where they connect in an appropriate manner to imaging circuitry and to an illumination source, respectively. As shown, the distance from the imaging assembly 40 to the outside of the chest wall is low, less than several inches. Preferably, at least the illumination light guide 50 is short, and of approximately this short length, so that a coupling, shown in FIGURE 1 as element 50a may be provided directly outside the body to transmit light to the interior with relatively little loss. This allows a relatively high energy level to be applied, for illuminating the very large area of field of view to be covered. Alternatively, the illumination source may employ a relatively low level of illumination, since this is sufficient to form images with a longer integration time. Moreover, since the large field view is to be used largely for general orientation, it need not have high spatial resolution.

The illumination source for the auxiliary camera 10 may readily piggy-back from the standard illumination source fiber output coupler that drives the primary endoscope 20. Indeed, the auxiliary endoscope may entirely lack a light source, relying instead on the light cast by the primary endoscope which will in general illuminate the major part of the field of interest over a shorter illumination path, and thus with higher intensity, than would a comparable source attached to the more remotely-positioned fixed panoramic endoscope 10. Finally, in yet another alternative embodiment, the auxiliary

endoscope may have a separate battery-powered or low voltage light source mounted at the port 55 (FIGURE 4) which may for example include a bulb coupled directly into the termination of bundle 50 at that point.

Such a directly illuminated auxiliary endoscope forms one presently preferred body of the invention, and is illustrated in FIGURE 5. As shown therein, the support 42 has an illumination bundle 50 extending therein to an illumination port 55 which is formed as part of the support itself. Mounted on the port 55 is a light assembly 60 which includes a bulb or laser source 65, a parabolic, ellipsoid or otherwise curved reflector 61 which either by itself or in conjunction with a lens and/or relay bundle (not shown) focuses or couples the output from the light 65 into the fiber bundle or light pipe 50. The light assembly 60 may include its own rechargeable power pack, or may be fed by a lightweight electrical supply cable, thus reducing loading on the cannula and column assembly 30, 42 and assuring that the imaging assembly 40 remains undisturbed in its fixed in position in the roof of the chest cavity.

As noted above, one of the more challenging tasks confronting the endoscopic thoracic surgeon is to carry out resections and, in the case of coronary artery bypass grafting, to harvest vessels imbedded in tissue in order to attach them to cardiac vessels and replace occluded portions of the vasculature. During such resections and harvesting of vessels it is necessary to cut through tissue, raising a major risk of cutting a vessel embedded therein. Such a mishap can lead to excessive bleeding, completely obscuring the field of view, and raising risks associated with such blood loss.

In a further aspect of the present invention, this problem is addressed by providing the imaging assembly 40 for viewing at infrared or thermal wavelengths, so that rather than a panoramic view of the surface operating theater, it images primarily heat distribution, effectively displaying the blood vessels, and may penetrate tissue to a depth of a millimeter or more. This renders the embedded vasculature visible before it is actually touched by a scalpel. Such imaging is achieved by several modifications of the illumination and imaging optics and equipment as follows.

Several structurally distinct embodiments of the fixed-mount panoramic camera of this invention for thermographic use are contemplated, and a brief discussion will aid in appreciating their structure and novel features. In general, imaging of the infrared radiation emitted by body tissue may be used to determine temperature of the tissue with an accuracy on the order of

.01-.1°C. However, the efficiency of detection for this very low energy radiation is low and its energy, by definition is close to the thermal energy of shot noise of material, so that cooling of detector arrays, for example, with liquid nitrogen has in the past often been necessary to reduce background noise and detect thermal images with efficiency,

using detectors formed of materials such as HgCdTe or GaAs/AlGaAs. Other IR detector elements such as ferroelectric ceramic bolometer elements as extensively described in the papers of R. Watton, P.A. Manning and others are capable of uncooled operation, but contrast is problematic. To applicant's knowledge this technology has not been applied to an endoscopic arena, and applicant believes that even the IR image characteristics of endoscopically-accessed tissue are poorly, if at all, known.

In accordance with one aspect of the present invention, a fixed mount endoscopic camera is provided with an IR sensing array as its image sensing element. No illumination source is provided, but instead a cooler, which is preferably a thermoelectric cooler, is incorporated in thermal contact with the array and/or its sensing or signal amplification circuitry. The support cannula carries only electrical signal wires for the sensing chip and support circuitry, and power connections for the thermoelectric cell (i.e. a Peltier cooler).

In this embodiment, a wavelength cut-off filter may be provided ahead of the sensor to remove wavelengths above five micrometers, thus providing a higher signal to noise ratio overall. A HgCdTe or similar sensor array may be employed as the imaging element, or a ferroelectric ceramic array may be employed, with appropriate electronics for signal processing.

In a further variation of a cooled imaging embodiment, an external cooler may be provided rather than a thermoelectric cooler, and the cooler is connected through the support column to the imaging element by a heat pipe. In that case, the external cooler mounts on the support column in the region corresponding to the light port 55 shown in FIGURE 5. The heat pipe may be a conductive solid, such as a rope of braided gold, silver or other flexible and highly heat conductive material.

Finally, a third thermographic imaging embodiment employs the IR detector element outside of the body where it is amenable to cooling of a conventional type. In this case, the view of the chest cavity is relayed directly as infrared image light, by a 45° mirror M (FIGURE 6) which directs the field vertically, up through the cannula to an infrared sensor array denoted IR. The mirror is shown schematically to perform both a path-turning and image-forming function, but may be replaced by conventional IR imaging elements in suitable combination to achieve this operation. For example a panoramic IR lens may relay a chest image to a flat or curved turning mirror to direct image light up through the shaft. The lower portion surrounding the mirror M may be a window or bulb Q formed of quartz or a suitable IR-transmissive material. Thus, this embodiment operates like a fixed-site periscope. Mirror M may be convergent, to cleanly direct the infrared image light onto the sensor array, and additional infrared-refractive relay lenses RL may be provided within the column 42 to relay the image from

the mirror M to the array IR. Additionally, one or more infrared focusing or corrector elements CF may be provided at the image sensor to correct focus or provide additional magnification.

So constructed, the thermographic endocamera provides a large-field thermal view of the thoracic cavity. In general, this view will reveal arteries with relatively high contrast and definition, providing a "road map" to avoid inadvertent cutting. As noted above, the IR image is a partially penetrating one, and the depth penetration may be further enhanced by selectively imaging at wavelengths that are not as highly absorbed by water.

In addition to a specialized thermally-sensitive camera arrangement as just discussed, the invention contemplates an image sensing array in which a particular or specialized color image is formed. The color image may be formed by an appropriate optical wavelength bandpass filter in the objective optics or on the sensor array, or may be formed after the fact by applying a digital filter to the detected color image. This imaging technique may be used to selectively display regions of tissue stained by a marker dye, or having a particular fluorescence response indicative of necrotic, cancerous or precancerous tissue. In that case, the light pipe 50 may be a conductor which carries the appropriate illumination, such as a UV or blue illumination to stimulate the sought-for fluorescent response. The camera may also operate with post imaging processing to display an artificial or derived image, such as a two-color differential response image, as has been used for some forms of diagnosis.

In each case, the auxiliary camera has an objective of front optical assembly fixedly located on the column 42 to provide an image of the chest cavity, and thus to provide an orienting view of the primary surgical viewing endoscope, the surgical implements and the regions surrounding the site of surgery.

The invention being thus described, further variations and modifications will occur to those skilled in the art and all such variations and modifications are considered to be within the scope of the invention and its equivalents, as defined by the claims appended hereto.

What is claimed is

CLAIMS

1. An auxiliary endoscope comprising:

a support member extending along a direction

an imaging assembly mounted at an end of said support member, and

a fixation mounting for fixing said support member at an opening to position the imaging member on the roof of a chest cavity and provide a view of the cavity.

2. An auxiliary endoscope according to claim 1, wherein said mounting comprises a multi-part structure movable between first and second positions, said mounting in said first position forming an enclosure about said imaging assembly for protecting the assembly during introduction through said opening, and said mounting in said second position contacting said roof for clamping said imaging assembly thereat.

3. An auxiliary endoscope according to claim 1, wherein said support member includes a column extending along an axis, and adapted for rotation about said axis to change direction of said imaging assembly within said cavity.

4. An auxiliary endoscope according to claim 1, wherein said imaging assembly is rotatable about a longitudinal axis for facing different directions in said cavity, and is movable about an axis transverse to said longitudinal axis for selecting angle of view within said cavity.

5. An auxiliary endoscope according to claim 1, wherein said column is slideably lockable for fixing depth of said imaging assembly in said cavity.

6. An auxiliary endoscope according to claim 1, wherein said imaging assembly includes an illumination assembly.

7. An auxiliary endoscope according to claim 6, further comprising a light guide extending from said imaging assembly, along said support to a light input port outside the cavity.

8. An auxiliary endoscope according to claim 6, further comprising a light source attached to said support externally of said mounting, and a light guide extending from said source to said illumination assembly.

9. An auxiliary endoscope according to claim 1, wherein said imaging assembly is a penetrating light imaging assembly for detecting subsurface vessels.

10. An auxiliary endoscope according to claim 1, wherein said imaging assembly is a thermal imaging assembly.

11. An auxiliary endoscope according to claim 10, further comprising a thermal cooler for limiting temperature of said imaging assembly.

12. An auxiliary endoscope according to claim 1, wherein said imaging assembly is a color imaging assembly adapted to produce a artificial color image identifying necrotic, marked or diseased tissue.

13. An auxiliary endoscope according to claim 1, wherein said imaging assembly includes a zoom assembly for changing magnification of an image formed thereon.

14. A method of endoscopic imaging, such method comprising the steps of

forming a surgical opening that accesses a body cavity, and

clamping an endoscopic camera to the opening such that the camera is suspended in the cavity to provide a fixed view thereof.

15. The method of claim 14, wherein the camera is a zoom camera and the step of clamping the camera suspends the camera such that it may be controlled from outside the cavity to change magnification.

16. The method of claim 14, wherein the endoscopic camera includes a thermographic imaging array which images without extrinsic illumination.

17. The method of claim 14, further comprising the step of producing color-enhanced images of said fixed view to identify tissue.

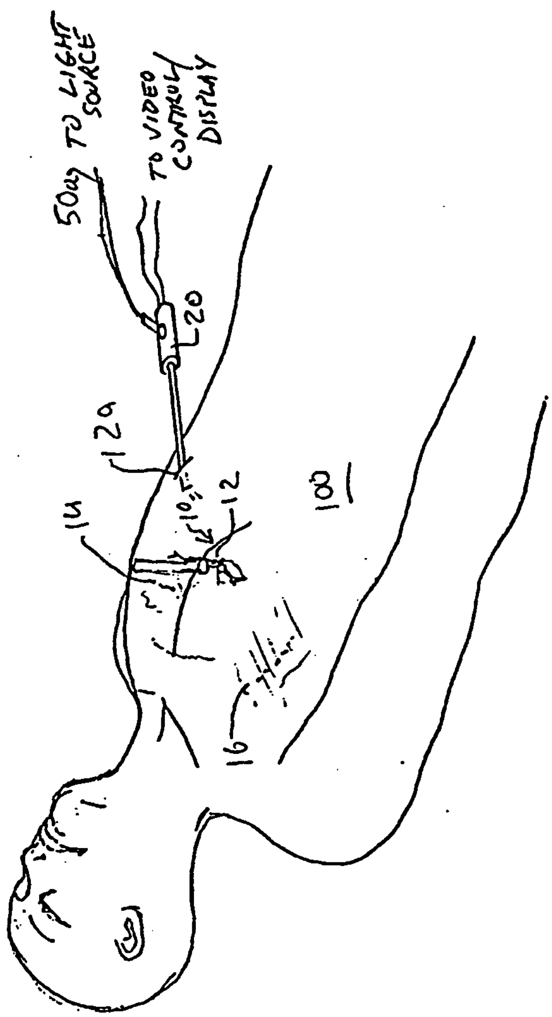
TO LIGHT SOURCE
TO VIDEO CONTROL DISPLAY
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FIG. 1

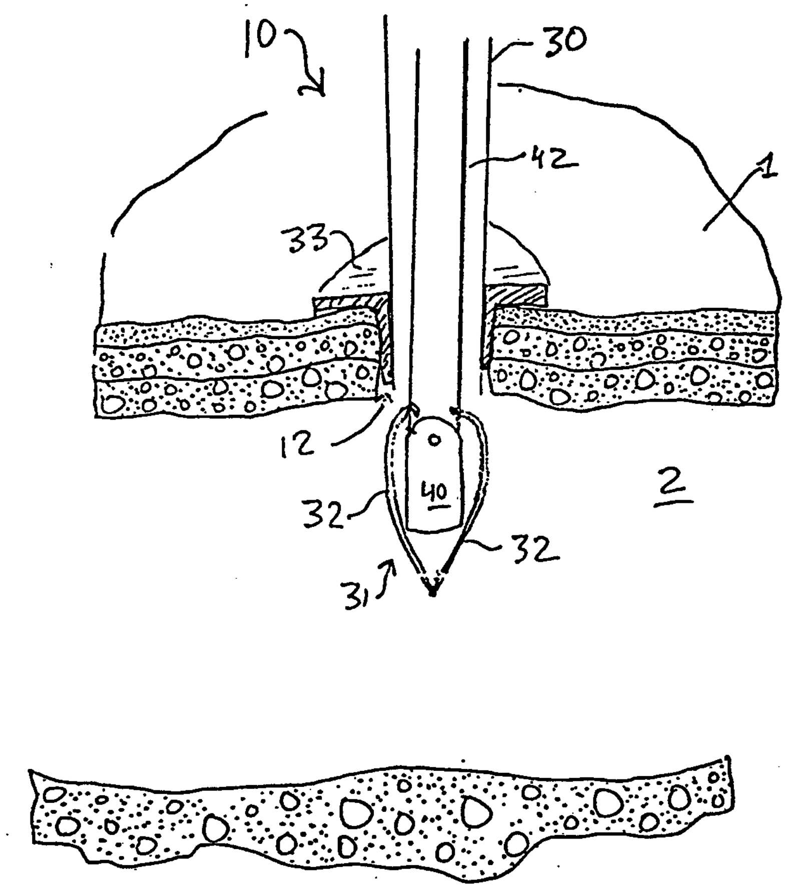


FIG. 2

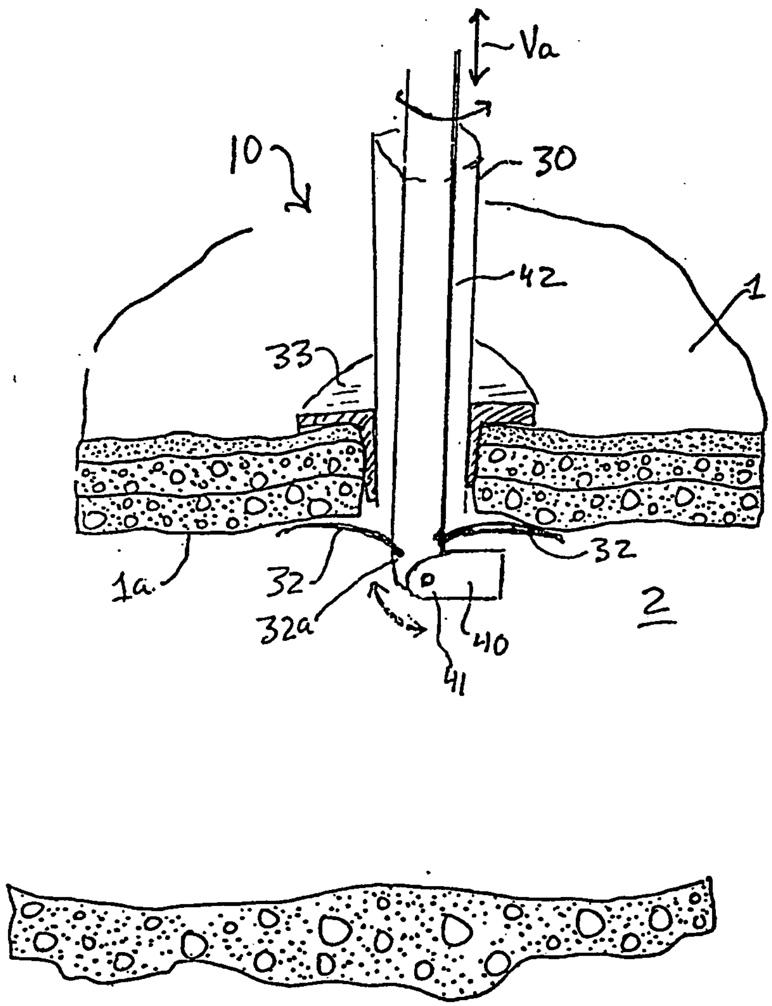


FIG. 3

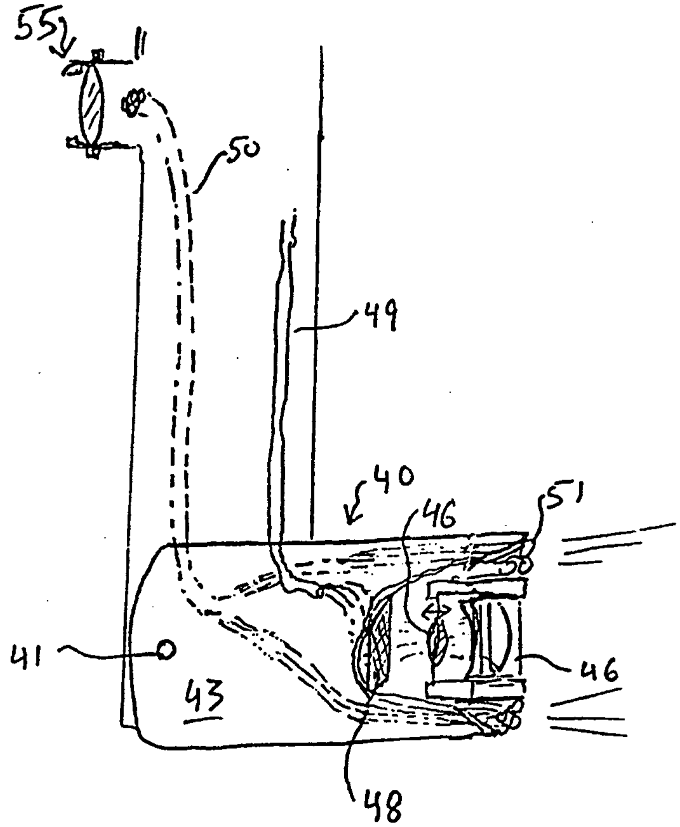
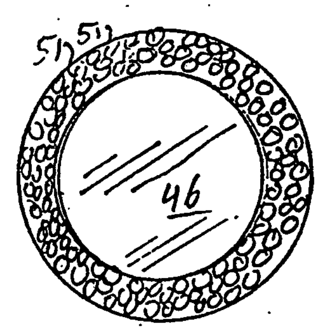


FIG. 4

FIG. 4A



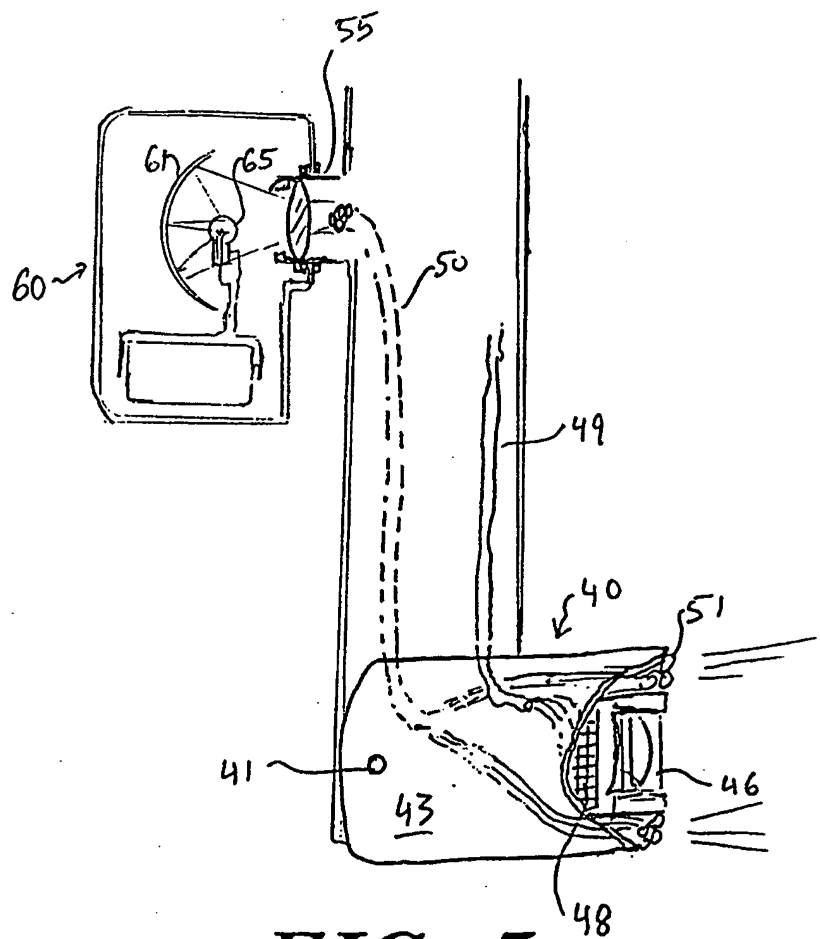


FIG. 5

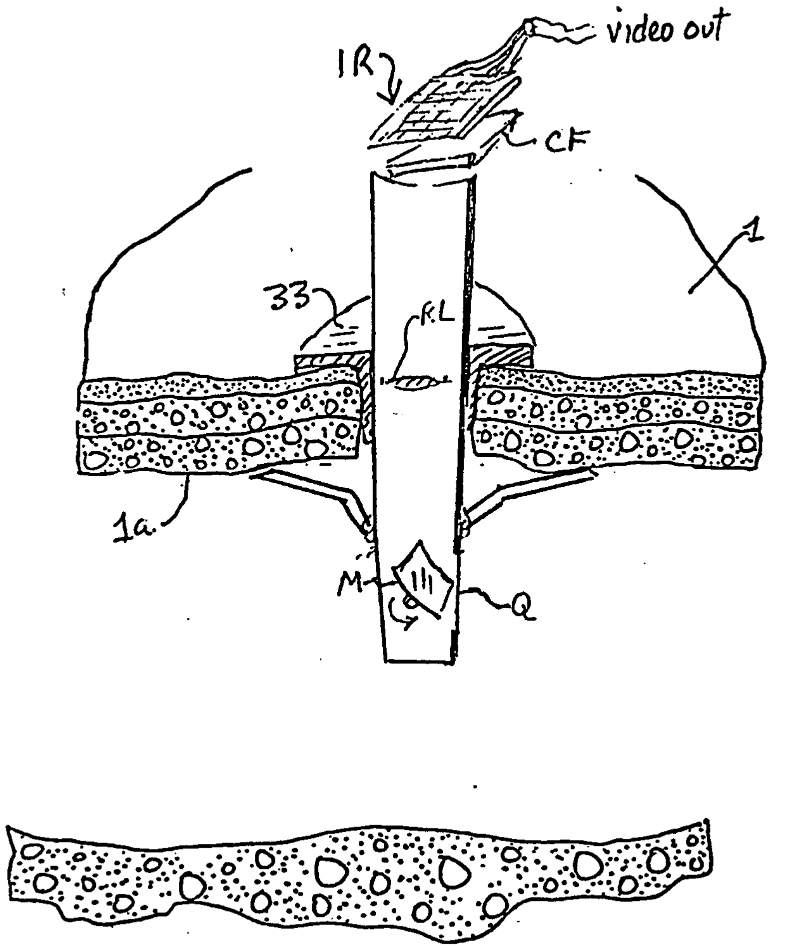


FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/01933

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61B17/34 A61B1/313

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 279 575 A (BRIGHAM & WOMEN'S HOSPITAL) 18 January 1994 see column 3, line 36 - column 4; figure 24	1,2,4-13
X	DE 94 14 957 U (N. LEMKE) 28 September 1995 see page 4, paragraph 2 see page 5, line 2 - line 3	1
X	US 4 686 965 A (BONNET LUDWIG ET AL) 18 August 1987 see figures 1,3,4	1
A	US 2 599 662 A (R. R. ROSENBAUM) 10 June 1952 see figure 1	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 1998	22.05.98

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gérard, B

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INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/US 98/01933

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 354 302 A (KO SUNG-TAO) 11 October 1994 see figure 2 -----	2

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inte. onal application No.
PCT/US 98/01933

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 14-17
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/01933

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5279575	A	18-01-1994	AU	4664393	A	15-03-1994
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US 2599662	A	10-06-1952	NONE			
US 5354302	A	11-10-1994	WO	9411052	A	26-05-1994